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Projectability in Design Science Research

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Abstract:

Design science research aims to be prescriptive, purposeful, relevant, and valuable. The propagation of design science theory, models, and principles is a key challenge. In this paper, we discuss this propagation issue and propose an alternative to the backward-looking concept of generalization; namely, the concept of *projectability*. We present projectability as providing a language for explaining how design theories and design principles, as prescriptive constructs, imply intentionality for operation in other places or times. In 2008, a special issue of *MISQ* published five design science exemplars. We analyzed the actual projection of the design theories and principles from these papers and found several notable actual projections for all five. However, in all but one case, the papers that developed the projections involved one or more of the original authors. This paucity of propagation indicates that DSR publications need better framing to enable their projectability. Hence, we propose a language and a projection process logic in six parts that better frame (and improve) such projectability.

Keywords: Counterfactual Conditionals, Design Science, Design Theory, IT Artifact, Future World, Generalizability, Local World, Possible Worlds, Project Management.

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1 Introduction

Design science is “a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process” (Simon, 1988, p. 68). In the information systems (IS) discipline, this doctrine materializes in the form of design science research (DSR). As a central tenet, much DSR work focuses on producing prescriptive knowledge products. However, while such work may indeed deliver prescriptive knowledge, we lack understanding about how future designs can follow and actualize these prescriptions. In DSR, “knowledge and understanding of a problem domain and its solution are achieved in the building and application of the designed artifact” (Hevner, March, Park, & Ram, 2004, p. 75). This dual nature in the DSR contribution (i.e., knowledge and artifact) perhaps represents the paradigm’s defining characteristic.

In the DSR paradigm, researchers produce knowledge in a setting that features endogenous pluralism: sometimes nomothetic, sometimes idiographic, sometimes scientific, and sometimes designerly (Baskerville, Kaul, & Storey, 2015). For some authorities, theory (especially design theory) can represent an important aspect of the DSR knowledge contribution (Gregor & Hevner, 2013; Gregor & Jones, 2007; Walls, Widmeyer, & El Sawy, 1992). For other authorities, theory does not represent a particularly important output in the paradigm (March & Smith, 1995; Österle et al., 2011). Further, DSR produces prescriptive knowledge, whereas the natural and social sciences produce descriptive knowledge.

While researchers widely regard the artifact as central in the paradigm, they have diverse opinions about what it is and how it matters. The popular definitions in IS range from March and Smith’s (1995) progressively specified constructs, models, methods, and instances to the more pragmatic we-know-one-when-we-see-one definition in Orlikowski and Iacono (2001, p. 121): “those bundles of material and cultural properties packaged in some socially recognizable form such as hardware and/or software”. Further, researchers have differing opinions about its importance in the IS discipline: some see it as the discipline’s core subject matter, while others see it as an ill-defined, overloaded concept that has grown meaningless due to overuse (Alter, 2015).

As a form of science, we might assume that DSR would share other sciences’ focus on discovering and formulating “in *general terms* the conditions under which events of various sorts occur, the statements of such determining conditions being the explanations of the corresponding happenings” (Nagel, 1961, p. 4, emphasis added). But two issues mainly cloud DSR results’ generalizability. First, much of what we understand about generalizability is anchored to descriptive knowledge that we have built on analyzing pre-existing empirical data. Thus, generalizability actually looks backward. It remains unclear whether these concepts fit well with prescriptive knowledge that, by its nature, prescribes future use. Second, researchers often express DSR theories as design principles or design theories. While such intellectual constructs ideally express a general solution to a class of problems, determining their scope and scale currently involves more art than science.

In this paper, as an alternative to the more backward-looking generalizability concept, we explain how projectability provides a forward-looking means to frame the future and, thereby, propagate the knowledge and artifacts that researchers develop in DSR. Armed with such a means, we also proceed to design a process to improve projectability in design science research.

The paper proceeds as follows: in Section 2, we discuss projectability’s theoretical background. In Section 3, we look at various concrete examples of design science research projections. In Section 4, we discuss what a more rigorous process for defining projectability could look like. In Section 5, we define a process logic for DSR projections: worldmaking. In Section 6, we discuss our results. Finally, in Section 7, we conclude the paper.

Contribution:

We propose *projectability* as an important quality of design theories, principles, and artifacts. Projectability refers to the utility of this design science knowledge in real-world design settings. It is anchored in the seminal work on generalizability. But projectability is a prescriptive alternative to the descriptive statements common in generalizability. Projectability is more suitable in design science research because it captures the pragmatic quality of design knowledge to operate usefully, in the past, the present, and the future.

2 Theoretical Background

We lack the scope in this paper to complete review all literature on DSR, design theory, and scientific generalizability. Since the work in these areas expresses diverse and sometimes conflicting opinions, we establish the underlying perspectives and assumptions necessary to understand the arguments in our work below.

2.1 Design Science Research and Its Artifacts

Researchers sometimes regard DSR as a research paradigm (Hevner et al., 2004; Iivari, 2007), as a venue for research methodology (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008; Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011; Vaishnavi & Kuechler, 2015), or as a form of engaged scholarship (Van de Ven, 2007).

For our purposes, we adhere to the view that DSR does not represent a separate academic discipline but rather a way to conduct research. Overall, it represents a multifaceted paradigm rather than a singular, step-by-step method (Iivari, 2007). Its major activities include analyzing design problems, designing and constructing artifacts to diminish problems, and evaluating these artifacts. As with most other representations of the paradigm, we regard these activities as iterative or cyclical. Hevner et al. (2004) describe a classic view of the iterative nature of the activities in a three-cycle build-and-evaluate model (Hevner et al., 2004).

DSR traces its roots to Herbert Simon's (1996) seminal work. His work elevated applied disciplines (such as medicine, business, economics, engineering) to sciences of the artificial. Simon logically separated the prescriptive knowledge that these disciplines develop from the descriptive knowledge that the natural and social sciences develop.

Simon (1996) also ennobled our learning from making artifacts and studying their environments before and after their placement. Artifacts embody an inner environment that delivers certain functions. A large measure of artifacts' utility concerns the degree to which this inner environment matches the outer environment together with how the outer environment reacts/changes in response.

As we mention in Section 1, one can conceptualize the artifact in various ways. Indeed, researchers have defined artifacts in many varied ways over the years. They chiefly vary in the degree to which an artifact should be embodied in a physical object or in an idea. This contrast does not simply replay Platonic idealism versus Aristotelian realism because design science deals with human productions rather than representations. The way in which March and Smith (1995) view design science products (constructs, models, methods, and instances) strongly invokes the artifact-as-an-idea viewpoint. Simon's (1996) view, with its machine-like notions of functions and interfaces, strongly invokes the artifact-as-a-machine viewpoint. While such contradictory conceptualizations cannot be resolved (Alter, 2015), we can usefully choose a working viewpoint for our purposes. Since we consider how both knowledge and artifacts propagate, we use "artifact" to mean either viewpoint and specify "conceptual artifact" if necessary to distinguish an artifact as an idea from Simon's machine orientation that refers to the *material artifact* as having such "material properties as features of IT, including hardware devices, software interfaces and applications, and communication services" (Robey, Raymond, & Anderson, 2012, p. 218). This distinction resembles Iivari's (2015) distinction between a meta-artifact and a concrete IT artifact.

2.2 Design Theory

Walls et al. (1992) proposed a specific type of theory for describing a general form of knowledge that might proceed from design activities. Design theories are consistent with other kinds of scientific theories (Gregor & Jones, 2007) although some scholars have challenged the process components that characterize design theory (Hooker, 2004). But, in rejecting such process components, this challenge leaves intact the salient relationship between meta-requirements and meta-design (Baskerville & Pries-Heje, 2010b). When we centralize meta-requirements and meta-design, we raise two important assumptions regarding generality in DSR knowledge and artifacts: functional explanations and technological knowledge.

2.2.1 Functional Explanations

Simon (1996) first associated functional explanations with the science of design. Functional explanations refer to a type of teleological explanation because an artifact's role in either its inner environment or its outer environment explains its functions. Researchers may not find such explanations as familiar as deductive ones; nevertheless, science has established the acceptability of such functional explanations (Nagel, 1961). For our purposes, the generality of these functional explanations must depend partly on the generality of statements about an artifact's inner environment's functions and its outer environment's requirements.

2.2.2 Technological Knowledge

Bunge (1998) distinguished between scientific and technological explanations. Scientific explanations are law like, nomological, and theoretical. They explain *why* things happen. Technological explanations are nomopragmatic and regulated. Rules express generalities in technological knowledge. They specify what we should *do* to make things happen. In order to make general statements relative to functional explanations, we invoke various forms of technological rules. "To achieve Y in situation Z, do X" represents a general example (van Aken, 2004).

Technological explanations often unfold in layers and over time. For example, a design usually comprises three distinct designs: the object design, the realization design, and the process design. Van Aken (2004, p. 226) used mechanical engineering to illustrate these layers:

> *The object design is the set of drawings of a designed machine, the realization design the set of instructions for the workshop on how to build that machine, and the process design the plan for the design process itself (involving steps like definition of requirements, sketching, making the outline design, making detail designs).*

Technological knowledge is pragmatic, diverse, and distributed across actors in design settings. In social design settings, such as designs for organizational development, the realization design (also known as "implementation design"; Drechsler, 2013) will emerge from the interaction between stakeholders and the object design. While developers create an original realization design beforehand, in practice, the actors in the organizational setting will redesign their new roles and activities and adjust both the object and the realization designs to fit the social and organizational setting (Huff, Tranfield, & van Aken, 2006; van Aken, 2007).

2.2.3 DSR Contributions

Gregor and Hevner (2013) depict the dual nature of DSR contributions as a continuum of three levels from more specific knowledge to more general knowledge (see Table 1). They essentially distinguish the material artifact (level one) from two different levels of DSR knowledge: the productions we label as above as an artifact as an idea (level two) and design theories (level three).

Table 1. Design Science Research Contribution Types (from Gregor & Hevner, 2013)

	Contribution types	Example artifacts
More abstract, complete, and mature knowledge	Level three: well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕ ↕ ↕ ↕	Level two: nascent design theory—knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules
More specific, limited, and less mature knowledge	Level one: situated implement of artifact	Instantiations (software products or implemented processes)

Considerations about operating an artifact in other places or times clearly pertain to level-one contributions. However, while the levels that Gregor and Hevner (2013) present allow one to position DSR results for publication, our purposes do not require the distinction between the second and third levels. Instead, DSR contributions' dual nature plays a stronger role in taking prescriptive knowledge to new settings while propagating material factors. We regard both design theory and design principles as technological knowledge because both are prescriptive and both invoke functional explanations. This position concurs with earlier work from Markus, Majchrzak, and Gasser (2002) who use design principles as a means to express a design theory.

Accordingly, we assume DSR features functional explanations that link an artifact's design to its environment's requirements. We assume that such explanations can be generalized technological knowledge (and, therefore, qualitatively different from more traditional forms of scientific knowledge with a basis in deductive explanations). We also relate the propagation of the material artifacts in DSR to the generality of the DSR knowledge used in the production of these artifacts.

2.3 Scientific Generalizations

Scientific assumptions about the necessity for general formulations about conditions for events (Nagel, 1961) can lead one to assume that generalizability directly relates to research's importance. In the philosophy of science, generalizations constitute "an 'all' statement to the effect that all objects of a certain general kind possess a certain property" (Lowe, 2005, p. 329). Law-like generalizations (that we care about here) differ from accidental generalizations because law-like generalizations support counterfactual conditionals (Goodman, 1955). An example law-like generalization is "all airplanes have wings". One can restate it as an indicative (or factual) conditional: "if a machine is an airplane, it has wings" (i.e., the basic modus ponens form of an antecedent that entails the truth of the consequent). An example counterfactual conditional is "if the machine had been an airplane, it would have had wings". An example accidental generalization is "all machines in the hanger are airplanes". When stated as an indicative conditional, it becomes "if the machine is in the hanger, it is an airplane". Such an accidental generalization does not support counterfactual conditionals: "if this motor car had been in the hanger, it would have been an airplane". Goodman (1955) and others claim that law-like factual statements reveal natural kinds of entities (i.e., entities identifiable by their innate properties). One can see kinds of entities that only incidental properties identify through the accidental nature of their counterfactuals.

In IS, authorities recognize multiple forms of generalizability, although they argue over their exact distinction and characteristics (e.g., Lee & Baskerville, 2012; Seddon & Scheepers, 2015; Tsang & Williams, 2012; Williams & Tsang, 2015). For example, Lee and Baskerville (2003) characterize the forms in terms of constructing statements about theory from statements about evidence (and vice-versa). One constructs generalizability differently depending on whether one generalizes from data to description (empirical statements to empirical statements), from description to theory (empirical statements to theoretical statements), from theory to description (theoretical statements to empirical statements), or from concepts to theory (theoretical statements to theoretical statements). For our purposes, we note that researchers have challenged the generalizing principle from theory to description (Seddon & Scheepers, 2015). This challenge is important to our purpose because the basic prescriptive nature of design theories and principles changes this form (theory to description) in a way that is not purely deductive. Instead, there is an emphasis on more interaction with, and rearticulation of, the theoretical statements (Carroll & Kellogg, 1989).

Experimental science often depends on such controlled settings and claims that results have general application. Science not only anchors such claims to evidence, but also to persuasive argumentation. Instead of attempting to operationalize general constructs, experiments often require "generalization at the linguistic level of the constructs" (Shadish, Cook, & Campbell, 2002, p. 18). (Shadish et al., 2002). Like experiments, designs in DSR "are highly local but have general aspirations" (Shadish et al., 2002, p. 18). A similar tension exists between the localized basis for DSR knowledge productions and the generalized goals for scientific knowledge. But DSR differs further because its prescriptive results not only affect non-local contexts but also may involve future applicability. DSR is not intended as only a descriptive history of past design work.

For example, Rossi, Purao, and Sein (2012) distinguish between four levels of theorizing and generalizing from design research. The first level "cast[s] the original problem as an instance of a class of problems" (Rossi et al., 2012, p. 5). The second level involves "re-conceptualizing the specific solution instance into a class of solutions". The third level involves "learning from the specific solution into design principles for a class of solutions" (p. 6). Finally, the fourth level "determines the range of generalizability for the design principles" (p. 6). In terms of techniques for creating this generalizability, many researchers assume that generalizations proceed automatically from theorizing. Rossi et al. (2012) suggest that following Kuechler and Vaishnavi's (2008) work on developing mid-level design theories and Gregor and Jones' (2007) work on design theories' anatomy can lead researchers to develop useful decision science generalizations.

While the struggling generalization process may not represent the ideal framing for design theories and material artifacts, alternatives exists. Transferability, for example, relates to forms of naturalistic inquiry such as action research (Guba & Lincoln, 1982; Lincoln & Guba, 1985). It is strongly qualitative. But while conceptualizations of generalizability primarily rest on the theorizing aspect and eschew the application side, transferability emphasizes the application side. It assumes a deep knowledge of both the “sending” and “receiving” contexts in order to ascertain whether sufficient congruence between the contexts exists (Lincoln & Guba, 1985, p. 124).

In other words, the theorizer determines generalizability. The applier determines transferability. In an ideal world, the same person does both. The concept of transferability is also less than ideal for use in DSR. DSR is often materially prescriptive (i.e., planning material artifacts for future contexts). Design studies have particular value because they apply beyond a single context-bound example (Williams & Pollock, 2012). Design scientists often design as-yet immaterialized future artifacts for as-yet poorly understood contexts. The many unknown contingencies, even with the immediate design context, explain why DSR typically involves iterative cycles. Usually, knowledge about future receiving contexts cannot sufficiently sustain transferability.

Accordingly, we assume that existing conceptualizations of such scientific concepts as generalizability and transferability fit poorly with DSR. The generalities in the sciences “have an air of ‘necessity’ about them in their subservience to natural law” (Simon, 1996, p. xi). Instead, the generalities in design science “have an air of ‘contingency’ in their malleability by their environment” (Simon, 1996, p. xi). Design scientists make general empirical propositions about designs that, “given different circumstances, might be quite other than they are” (Simon, 1996, p. xi).

2.4 Projectability

Nelson Goodman (1955), widely cited for his seminal philosophy in generalizability, developed the projectability concept as a means to distinguish realized (factual) and unrealized (counterfactual) antecedents in scientific generalizations. A projection refers to any relevant instance that supports a theory:

> *The problem of confirmation, or of valid projection, is the problem of defining a certain relationship between evidence or base cases on the one hand, and hypotheses, predictions or projections on the other.* (Goodman, 1955, p. 87)

Projectability refers to a design theory’s quality to support such projections. To be projectable, a theory must meet three criteria: 1) one must be able to project it, 2) it must have no known violations (observations that oppose the theory), and 3) some possible but unexamined instances must exist. For a theory to have actually been projected, researchers must have already examined some (but not necessarily all) of the theory’s possible instances. For a theory to be entrenched, many projections must have already used the theory (Baskerville & Pries-Heje, 2014; Goodman, 1955, pp. 87-95).

One might view projectability as somewhat more primitive than generalizability. Goodman (1955) used it as a means to distinguish factuals from counterfactuals. On its own, however, it both accepts contextual contingency and values empirical histories. The more refined notions of generalizability suit descriptive research that values causal statements (e.g., X causes Y). Generalization describes and explains the history of regularities or consistencies that have previously existed or currently exist.

In contrast, one might view projectability as somewhat less primitive than reusability. In computer science, researchers regard reuse as the process of creating systems from existing artifacts rather than building systems from scratch (Krueger, 1992). Reuse most often involves taking a part or bit from one assembly and integrating it into another assembly. Software development has idealized reuse as copying existing software objects or subroutines for use in other software systems.

Projectability better suits prescriptive research (e.g., DSR) that also values purposeful statements in context (e.g., I want to achieve Y in situation Z, and, therefore, I will do X). Projection can also prescribe and propose possible regularities or consistencies that one could create to construct future worlds. The term encompasses the action-oriented propagation of material artifacts and their design theories and principles.

2.4.1 Context: Local Worlds and Possible Worlds

In the philosophy of science, the distinction between the factual and counterfactual antecedents necessary in both generalizability and projection also raises the distinction between local and possible worlds. “A possible world is a world that differs in some way from our ‘actual world’” (Crane, 2005, p. 745). Factual statements refer to an actual world. Counterfactual statements refer to possible worlds. Like counterfactuals, prescriptively projecting design theories, principles, and their material artifacts into future contexts invokes possible worlds that would incorporate such artifacts. This multi-world concept extends to possible worlds that could have been, the degree to which such possible worlds are real, and the spatiotemporal distance between our actual world and possible worlds (Lewis, 1986). Conceptually, a local world refers to the spatiotemporally closest possible world to our actual world. Being prescriptive, DSR deals with possible worlds that could be and the spatiotemporal distance between our actual world and a desirable possible world. As Buchanan (1995, p. 25) states: “Designers deal with possible worlds and with opinions about what the parts and the whole of the human environment should be”.

Accordingly, we consider projection and its underlying concepts local and possible worlds as having good potential for use as an alternative to generalizability in conceptualizing how DSR theories, principles, and material artifacts propagate. Both generalizability and projectability are *qualities* of theory. They do mutually exclude each other. The presence of such an alternative does not rule out the possibility that a theory can be both projectable *and* generalizable. We show the major distinctions between the qualities of generalizability and projectability as we describe them above in Table 2.

Table 2. Major Distinctions between Generalizability and Projectability

	Generalizability	**Projectability**
Logical form	Factuals	Counterfactuals
Basis	Empirical histories	Contextual contingency Empirical histories
Operation	Describe and explain history of regularities or consistencies that exist or have existed	Prescribe and propose possible regularities or consistencies that could be created
Context	Local world	Possible worlds

2.4.2 Example: Generalizability and Projectability of a Simple Theory.

In this simple example, we illustrate the difference between generalizability and projectability using a simplified theory that states why organizational activities might become more visible when activities become automated (Zuboff, 1988). The examples refer to the distinctions drawn from Table 2.

Generalizability

Logical form: increased automation leads to increased visibility of organizational activities because the devices create new information streams.

<u>Basis</u>: previous measures of the increased use of automation have correlated with increased flow of information throughout the organization.

Operation: describes and explains the historical consistencies between increased automation and increased availability of information.

Context: local world (closest to the actual world).

Projectability

Logical form: If we had used our profits differently, we could have increased automation; it would have led to increased information flow because the devices would have generated more data about their use.

Basis: an imagined context with available profits, and previous measures of increased information flow have correlated with increased automation.

Operation: prescribe and propose to use profits differently to increase automation in order to improve availability of information at all organizational levels (especially lower levels).

Context: possible world (one in which more profits are used for automation and employees are better informed about organizational operations).

The above example illustrates a theory that exhibits qualities of both generalizability and projectability. Other theories could be generalizable but not projectable. For example, consider “tyrannosaurus became extinct because of an asteroid-induced planetary winter”. One can generalize this theory into “all large animals became extinct because of a planetary winter” (cf. Lee & Baskerville, 2012). But it fails the first projectability criterion: one cannot project it (we cannot instantiate a possible world with a planetary winter).

3 DSR Projections

Projectability seems to pose a problem for design science research. While one can find examples in the literature, few exist, and one cannot easily identify them. A design theory’s or an artifact’s broader usefulness often relates to its theoretical contribution rather than its practical contribution. Nevertheless, researchers have speculated on possible projections, and evidence of actual projections exists. An *actual projection* means that a designer used the design theory to create a novel artifact. But, even in the best venues, researchers have poorly framed these projections. For example, *MIS Quarterly* published a special issue on design science in 2008. We chose examples of design science research published in this issue for several reasons. First, *as* a prominent, well-regarded, and highly selective journal, *MIS Quarterly* should contain high-quality work at the time of publication. Second, the work in the special issue have circulated for a sufficient number of years to raise our expectation that researchers would have realized some high-quality projections and published them in the literature. Third, the special issue editors introduced the issue by clearly summarizing the artifact in each work. We used this description to more clearly identify the anticipated projections of each artifact and to discover actual projections of the artifact subsequent to the special issue.

All the papers in the special issue contained artifacts and described instantiations. Hence, in Gregor and Hevner’s (2013) terminology, they all constituted level-one contributions. Projecting a level-one artifact involves predicting to what extent it can and will operate in other places and times.

Table 3 details the five papers in the special issue, the papers’ artifacts as the editors described them, and the anticipated projections as the authors described them. Based on these details, we then examined the publications listed in ISI Web of Science that cited the special issue papers. We looked for actual projections of the artifacts in subsequent published works. We purposely chose the ISI index due to its selectivity with regards to quality than alternatives (e.g., Google Scholar). While we may have eliminated more practice-oriented projections with this decision, we gained more assurance that these actual projections were substantial. By substantial, we mean that the actual projection led to a distinct contribution notable because the possible world of the actual projection was substantially different (in terms of originality) from the local world.

Our choice to use ISI and subsequent published works does not infer that we do not see value in projections in industry. For example, we have found evidence that industry has used Pries-Heje and Baskerville’s (2008) paper. Specifically, Pries-Heje and Johansen (2014) describe how 44 companies used the organizational change strategy nexus to make a strategic plan for an organizational change. These instantiations of the design theory nexus at level one may have had immense value for the 44 companies. However, we cannot review all industrial projections. Indeed, some would likely even see their use as proprietary knowledge. Hence, we have concentrated on published work.

We needed to carefully examine the citing papers to determine whether they cited the special issue papers for their more general concepts or to actually develop an actual projection of the artifact as the editors of the special issue described.

We found several notable results. First, the editors and authors clearly stated the artifacts and their anticipated projections. Second, in a relatively small span of years (in the academic world), researchers have made several notable actual projections of these works. Third, in all but one case, the papers that developed the projections involved one or more of the original authors. This continuity in the characters involved suggests that one cannot easily make actual projections of DSR artifacts without deep knowledge about their projectability. We believe it indicates that DSR publications need a better framing to enable their projectability. We propose below a language to frame (and improve) such projectability.

Table 3. Artifact Projections in the 2008 *MIS Quarterly* Special Issue on Design Science Research

Article	IT artifact (per March & Storey, 2008)	Anticipated projections	Actual projections
Pries-Heje & Baskerville (2008)	Constructs and methods that offer a unique problem-solving approach for developing decision systems for ill-structured and multi-criteria decision-making situations.	• The usefulness of the approach in non-IT areas and with non-IT people • A general version of the design theory nexus IT artifact • Exercise the artifact and the method to construct the artifact in more and larger organizations • (See page 751 in Pries-Heje & Baskerville, 2008)	• 37 citing papers in the ISI Web of Science • As a multi-sourcing decision tool (Lee, Baskerville, & Pries-Heje, 2015). • In business process crowdsourcing (Thuan, Antunes, & Johnstone, 2014)
Lee, Wyner, & Pentland (2008)	Grammar-based method to generate and manage business process design alternatives and software prototype (instantiation) that supports the method	• Add features to the software, such as a feature that organizes the exploration history in the form of a design space rather than simple chronological order • Using these artifacts in real organizations with attention to scalability (See page 776 in Lee et al., 2008)	14 citing papers in the ISI Web of Science No projections
Adomavicius, Bockstedt, Gupta, & Kauffman (2008)	Constructs and methods used to develop an ecosystem model of technology evolution	• Explore the directionality of paths of influence (negative as well as positive) • Forecasting future technology trends with quantitative analysis of transitions lags between patterns of the trends • Integrating the artifacts with array of newer business intelligence tools (See page 804 in Adomavicius et al., 2008)	20 citing papers in the ISI Web of Science • "A practical estimation approach for identifying and quantifying cross-level supply-side effects in the introduction of new information technologies" (Adomavicius, Bockstedt, & Gupta, 2012, p. 398)
Abbasi & Chen (2009)	A design framework for text-analysis systems instantiated in CyberGate, a software system.	• Improved design framework and CMC systems with enhanced text-analysis capabilities (See page 834 in Abbasi & Chen, 2008)	21 citing papers in the ISI Web of Science No projections.
Parsons & Wand (2008)	Model of good classification structures; rules to help one identify classes in conceptual modeling.	• Use in other IS contexts that involve class identification, semantic data modeling, object-oriented analysis, and ontology development • Explore ease of use, effectiveness, efficacy (See page 858 in Parsons & Wand, 2008)	19 citing papers in the ISI Web of Science • "Extend the use of the principles to other fields of research. For example, distinguishing the concepts of category and class helps in understanding why the debate over the demotion of Pluto from planetary status is a non-issue" (Parsons & Wand, 2013, p. 250)

4 DSR Projectability

In descriptive science, we justify generalizations through a “virtuous” circle in which we bring empirical statements and theoretical statements “into agreement with each other” (Goodman, 1955, pp. 67). That is, we justify empirical statements by their conformity to theoretical statements (i.e., deductively) and theoretical statements by their conformity to empirical statements (i.e., inductively or abductively). This justification is a conceptual process by which scientists progressively adjust both generalizations and the related inferences from observations in order to improve the logical fidelity.

In a prescriptive science, like DSR, the justification process slightly differs. It is still a virtuous circle that focuses on justifying design principles or theory across projections. However, differing possible (local) worlds will pose differing requirements and, thus, hinder agreement between theory and requirements. As a result, the design principles or theory will take different forms as they propagate into different possible worlds according to the local context. Unlike descriptive science, which focuses on a single generalization as the ideal, prescriptive science idealizes a family of related projections across differing possible worlds. Members of this family of design principles may be spatiotemporally closer or distant depending on the closeness of the possible worlds. Thus, entrenchment of design principles or theories involves their existence as a population of related versions, each appropriate for their particular context.

One can logically justify both descriptive and prescriptive theories. But the way empirical justification operates differs between descriptive and prescriptive theories. In descriptive scientific empirics, one focuses on confirming or falsifying a descriptive theory. In DSR empirics, one focuses on entrenching a prescriptive theory using future instantiations (actual projections) across multiple contexts (worlds). One empirically justifies design principles or theories by their prescriptive projectability, not their descriptive generalizability. That is, the empirical justification lies in consequence of the theory for further designs and the propagation of the theory to future designs.

We define descriptive theories as projectable according to three conditions (see Section 2.4): 1) one must be able to project it, 2) it must have no known violations (observations that oppose the theory), and 3) some possible but unexamined instances must exist. We can translate these conditions to design principles and theories as follows. The theoretical design statements must be in a form that allows one to project them. This condition is similar to that of generalizing from descriptive theories. One cannot anchor the terms in the theoretical statements too tightly to the actual world in which one develops the design. For example, a theoretical statement about an accounting manager is less abstract than a theoretical statement about a manager. A theoretical statement about a QED corporate accounting manager is less abstract than a theoretical statement about an accounting manager (cf. Lee & Baskerville, 2012, Appendix A).

For prescriptive theories, imperative statements are more projectable when one allows actors in possible worlds make necessary adaptations. For example, the logic of technological rules can include useful ambiguity: to achieve Y in situation Z, do something like X (Baskerville & Pries-Heje, 2010a). One may not even be able to project design principles and theories that adopt overly precise terms to the closest possible worlds.

For example, “building an information system design theory for vigilant EIS” (Walls et al., 1992) appears projectable to other possible worlds that need vigilant executive information systems but also to worlds that need executive information systems or vigilant information systems. “A theory of decision support system design for user calibration” (Kasper, 1996) seems projectable to other worlds that require better decision support systems and also worlds that require users to calibrate systems. “A design theory for systems that support emergent knowledge processes” (Markus et al., 2002) seems projectable to worlds that require knowledge management systems or emergent systems.

4.1 Closing Local and Possible Worlds

Lewis’s (1986) conceptualization of the spatiotemporal differences between possible worlds and between local and possible worlds offers a critical way to consider how design theories and principles (together with their material artifacts) propagate. For example, Markus et al. (2002) describe how they developed a technical artifact named TOP Modeler for four companies (Digital Equipment Corporation, General Motors, Hewlett-Packard, and Texas Instruments). Subsequently, at least ten other diverse organizations such as U.S. manufacturers and a high-tech subsidiary in Singapore used the system. Markus et al. originally based their emergent knowledge processes (EKP) design theory on four possible worlds (each of which was also local and actual in their own situations). The challenge for the TOP model designers involved basing their design in an abstract possible world with a minimum spatiotemporal difference to the four manufacturers' worlds. Digital Equipment Corporation, Hewlett-Packard, and Texas Instruments each had a low spatiotemporal distance between their possible worlds because, as U.S.-based computer electronics manufacturers, there had basic similarities. Because GM was in a different industry (an automotive manufacturer), the distance to the GM possible world was likely to have been greater. The distance between the possible worlds of the original TOP Modeler developers to the other U.S. manufacturers and the Singapore subsidiary possible world was likely to have been greater still. For example, the distance to the Singapore subsidiary possible world would be longer both in terms of physical distance and time distance (since the projection took place in a later time period).

This example has some notable key features. First, the design theory and principles originated from a possible world but not an actual world. The projections reached out to many local worlds of varying spatiotemporal distance to the possible world of EKP and TOP modeler. Second, localizing the design theory, principles, and artifacts involves closing the distance between possible worlds. In the development stage, the TOP model developers iteratively developed the theories and artifacts to fit the four initial manufacturers' needs. That is, EKPs' local world moved closer to the companies' possible worlds. The experience, especially at adoption time, also changed the manufacturers' local worlds by closing the distance between their local worlds and EKPs' possible world. These changing distances mean that the possible worlds are in motion. The projections are closing the distances between each designer's local world and the possible world of the future (usually a desirable one). Indeed, as TOP Modeler became commercialized, later adopters, such as the Singapore manufacturing subsidiary, independently designed to project the TOP Modeler design theories into their possible world. Such projections closed the distance between their local world and their possible world (a world that then included TOP Modeler).

4.2 Adapting Counterfactual Conditionals

We can also use the example that Markus et al. (2002) present to illustrate how the factual and counterfactual statements operate in the projections. Table 4 lists examples of related prescriptive statements in their design theory.

Table 4. Examples of Factual and Counterfactual Conditionals in Design Science Products

Markus et al. (2002) design science products	Prescriptive factual-like statement	Prescriptive counterfactual conditional
Design theory (fragment)	Because designers cannot identify specific types of users, the system should be self-deploying.	If the system had been intended for all types of users, it should have been self-deploying.
Design principle	Because designers design for customer engagement, they should seek out naïve users.	If the designers designed for customer engagement, they should have sought out naïve users.
Material artifact	Because designers intend the system for naïve users, it should have a "Ferris wheel" (p. 192) interface to convey the entire array of considerations.	If designers intended the system for naïve users, it should have had a Ferris wheel interface.

The imperative mood (i.e., "should") denotes DSR statements' prescriptive and imperative nature. Since the statements lack factuality, they have a diminished claim to generalizability. Nevertheless, they are eminently projectable since one can examine instances of them (as in Markus et al., 2002). We may also characterize the statements as having scientific projectability since the counterfactuals operate correctly.

To illustrate the effect of incorrectly formulated prescriptive statements in surfacing accidental (rather than scientific) generalizations in projections, consider the following pair of factual and counterfactual statements.

> Factual statement: because the system has a Ferris wheel interface to convey the entire array of considerations, the users will be naïve.
>
> Counterfactual statement: if a user had used a system with a Ferris wheel interface, the user would have been naïve.

These statements assume that only naïve users will (or can) operate a Ferris wheel interface. They project poorly because they imply that one can make (expert) users become naïve. The counterfactual reveals how the accidental generalization in the first statement assumes that anyone will be made naïve by using the system. Such accidental projectability cannot operate correctly.

The examples also illustrate how possible worlds move. The statements suggest a *local* world in which developers cannot use the TOP Modeler system is unusable because its inner environment includes an interface that does not match its environment (its local world). The statements present a *possible* world in which the interface matches its environment. The design theory and principles determine a different (revised) material artifact with a different (revised) interface. It would be a self-deploying artifact. Modifying the artifact and reintroducing it into the environment would move the local world closer to this more desirable possible world.

An alternative approach might have been to educate the naïve users. This alternative possible world would have sophisticated users. In such a world, the existing artifact, with its existing internal functionality and interface, would operate with its different (revised) environment. Changing the users rather than the artifact would move the local world to a possible world that significantly differed from the one with the self-deploying system. But this alternative would require a different theory and a different set of factual-counterfactual statements. In terms of projectability, the factual-counterfactual statements have a strong relationship with the movement toward possible worlds.

5 Worldmaking: An IT Process Logic for DSR Projections

In the descriptive sciences, researchers regard judgments about projectability as a posteriori (Boyd, 1991). That is, such judgments reflect whether the theory at hand compellingly explains the available empirical data. These judgments depend on actual projections. In DSR, however, one must a priori make some important judgments about projectability in anticipation of an actual projection. On the one hand, one must make such judgments about design theories, principles, and artifacts in the local world. On the other hand, one must consider how these design theories, principles, and artifacts will explain a possible world.

In order to support such explanations, one must express the design theories, principles, and specifications in prescriptive, factual-like statements. Such statements will support prescriptive counterfactual conditionals as Table 4 illustrates. These statements provide the functional explanations important in DSR and set up a priori prescriptive projectability judgments.

Goodman (1978) uses the notion worldmaking to account for the manner in which people descriptively create their own worlds through art, poetry, and so on. It requires “seeing beyond being” (p. 71). Our statements do not regard what we see before us but are rather prescriptive factual-like statements that regard seeing what is *not* before us. He further enumerates some of the ways in which such worldmaking unfolds, such as composition, decomposition, weighting, ordering, deletion, supplementation, and deformation. Composition and decomposition refer to the repetitive, often conjoint, analysis, synthesis, taking-apart, and putting-together operations that can result in creating identities: naming kinds of entities in the world. Weighting often involves emphasizing some kinds of entities over others: distinguishing the world’s relevant entities from the irrelevant entities. Ordering forms the basis for all measurement: it may regard periodicity, proximity, or derivation (entities may derive from other entities). Deletion and supplementation have a key role in making one world out of another: eliminating old material and introducing new. Deformation involves reshaping and distorting entities to fit a changing purpose.

Goodman’s (1978) worldmaking provides insight into how people move their local world closer to a possible world. From a DSR perspective, we apply these insights to develop a logical process by which people can develop artifacts as a means to move toward a possible world. That is, we convert descriptive statements to prescriptive statements. We admittedly take a software engineering viewpoint since much IS DSR concerns software artifacts. Table 5 relates Goodman’s (1978) ways of worldmaking to the process logic in projecting DSR theories, principles, and artifacts into an environment.

Table 5. Projection Logic related to Goodman's Ways of Worldmaking (1978)

Ways of worldmaking (Goodman, 1978)	Characterization	Projection process logic
Seeing beyond being		Express design theories, principles, and artifact specifications in prescriptive factual-like statements. Verify these statements by checking the validity of prescriptive counterfactual conditionals.
Decomposition	Analysis and taking-apart operations that can result in naming kinds of entities: repetitive and often conjoint with composition.	Recursively analyze the local world, identify the kinds of entities in the proposed artifact's environment.
Weighting	Emphasizing some kinds of entities over others: distinguishing the relevant from the irrelevant.	Determine relevant entities and their importance.
Ordering	The basis of measurement: periodicity, proximity, or derivation.	Determine important kinds of entities to retain.
Composition, deletion, and supplementation	Making one world out of another: synthesis, putting together, and eliminating old material and introducing new material; creating identities.	Create the material artifact (new entities), delete obsolescent or conflicting entities in the environment.
Deformation	Reshaping and distorting entities to fit a changing purpose.	Adjust remaining entities to conform to the material artifact.

5.1 The Practice of Projection Using an Analogy to IT Project Management

But exactly how could this projection logic operate in practice? IT design and development in a local world often occurs in a project; such a project constitutes a temporary endeavor to create a unique product, service, or result. In IT projects, one has to project measurable organizational value (Marchewka, 2014) and estimate future work. Thus, we decided to use the relative well-developed IT project management discipline as analogy to projection in DSR. In the following examples, we translate the projection of design theories and principles into project management practices. This translation illustrates how projection logic can unfold when one actually practices design science research.

5.1.1 Generate and Validate Design Statements

One must prescribe the material artifact's design in statements that implement (or adapt) the design theories or principles. Researchers sometimes call these statements design rules (Hanseth & Lyytinen, 2010). For example, the design theory might state "all airplanes have wings". The design rule might state: "In order to achieve flight in an aerial situation, the X4 Bantam airplane is designed with wings". One can scientifically validate such statements by checking the counterfactuals.

Essentially, these statements constitute the projection logic for describing the new entities intended to inhabit the possible world (the intended new local world). In project management, this logic translates into the practice of identifying work packages. It involves dividing a product's (the projected entity or artifact) features or functionalities into work packages. (Haugan, 2002; Norman, Brotherton, & Fried, 2010)

5.1.2 Analyze and Weigh Existing Local World Entities

This logic involves analyzing the entities that already exist in the local world and assessing their relevance and importance to the new entities that arise from the design theories and principles. This logic is sometimes recursive because discovering a related entity can lead one to discover other connected entities.

This problem is familiar in project management. One often creates a cost-benefit analysis or business case to decide whether one should turn an idea into an actual project. Such a case is a possible world where one imagines the project's artifacts to exist. This possible world answers questions about what organizational value could proceed from the project idea. This process is difficult (Boardman, Greenberg, Viking, & Weimer, 2010) with a lot of uncertainty.

5.1.3 Weigh the Existing Local World and New Possible World Entities

Further, in a cost-benefit analysis, one predicts the cost that one will incur from conducting the project. In other words, one makes an estimation. For Nelson (2007), organizations are traditionally poor at estimating IT projects.

Estimates for a project predict how much time, effort, or money it will it take to do a given “thing”. Hence, good estimation highly depends on the estimator’s knowledge and the thing’s characteristics. Estimation involves two main activities: reducing complexity and gathering more knowledge about the thing. Reducing complexity resembles what Goodman (Goodman, 1978) calls worldmaking—especially its composition, decomposition, and weighting processes.

Gathering more knowledge about the thing when the thing constitutes a design theory could involve actually locally projecting it (or part of it). However, one needs to evaluate that projection to obtain new knowledge. In other words, we add projectability to the criteria we can evaluate. Thus, traditionally when evaluating a design, one would evaluate things such as efficacy, effectiveness, ethicality, and so on (for an overview, see Venable, Pries-Heje, & Baskerville, 2016). But these evaluation criteria typically consider only the localized instance. Evaluating projectability may differ from such localized evaluations. It could, for example, involve localizing the design theory and principles to another user group, to another organizational context, or to another related but different problem situation. This projectability evaluation would then provide knowledge that we could use to more precisely predict users’, organizations’, and/or problem situations’ projectability.

5.1.4 Determine Which Kinds of Entities are Important to be Retained

This logic involves ordering the entities (new and old) according to their value in the possible world (the new local world). In IT project management, the estimation process involves not only predicting a “good” estimate for cost, time, or effort but also predicting the involved risk. This estimation, however, can be tricky because risks may be relative and unique to the person doing the estimation (Öbrand, Holmström, & Mathiassen, 2018). To handle risks, one often tries to more than simply predict the future. Thus, one would, for example, provide a best, a worst, and a most likely case (Lichtenberg, 1974; Project Management Institute, 2013). Along the same vein, in relation to a design theory, one would consider three possible worlds: a likely possible world, a best possible world, and a worst possible world.

5.1.5 Create the Material Artifact

This process logic sets in motion the transition from the local world to a possible world. The transition generates the material artifacts (the new entities). This new local world might be temporary (e.g., if the artifact is only an experimental design prototype) or it might displace the former local world forever (e.g., the artifact is an operational system). In the latter case, the transition may involve deleting obsolescent or conflicting entities in the environment, such as old systems.

Essentially, developing possible worlds that now include the material artifact represents the DSR build cycle. In IT project management, this cycle involves controlling the execution of work progress. Project managers monitor progress against the original plans, and, as the construction unfolds, they adjust the estimations accordingly.

5.1.6 Adjust the Context to Fit the Material Artifact

This process logic completes the possible world (the new local world) by making such adjustments that the new artifact (the new entities) may need to work. In Simon’s (1996) terms, the artifact will have an inner and outer environment and an interface. In most cases, the interface should ideally fit the outer environment perfectly. But IT project managers know well that, in some cases, the context has to fit the new system (rather than vice versa). For example, standard ERP systems sometimes require organizations to reengineer their processes to match the systems (i.e., the new artifact requires the organization to adapt to it) (Vilpola, 2009).

In this new local world, one must deform these pre-existing entities to conform to the material artifact. In IT project management, managers often regard these adjustments as part of the organizational implementation process. This process ends with an evaluation (Hallikainen, Peffers, & Saarinen, 2005) that completes the transition from the pre-existing “as is” situation to the projected “to be” situation planned in the initial scoping process (cf. Beer & Nohria, 2000; Kotter, 1996). This possible world now becomes the new local world.

5.2 An IT Process Logic for DSR Projection

Based on discussing the logic of DSR projection and project management theory on estimation, we now generate the following process logic:

1) Express design theories, principles, and artifact specifications in prescriptive factual-like statements. Verify these statements by checking the validity of prescriptive counterfactual conditionals.
2) Recursively analyze the relevant/important kinds of entities in the local world.
3) Generate three possible worlds: a likely, a best, and a worst possible world. Involve experts (e.g., colleagues, reviewers) when doing so as a bottom-up process that considers similar design theories to the one at hand. Any experts that one involves should preferably have insight into the design.
4) Determine which kinds of entities in the local world the three possible worlds should retain. Make this determination by examining the most likely possible world, the best possible world, and the worst possible world.
5) Plan the projectability evaluation by adjusting entities into a material artifact. Carry out the localized evaluation and obtain knowledge on how well material artifact was projected.
6) Adjust entities to conform to the material artifact and to the newly gathered knowledge.
7) Repeat as needed (the iterative cycle).

Figure 1 graphically represents this logic. We can refer to the logic as a projection process logic because, although there the six elements follow an implicit temporal order, they do not necessarily follow the same course. The elements may recur or coincide.

Elaborating a projectability process logic is important because it offers a step-by-step path by which one makes design theory projections into new or alternative settings other than the original design setting. Table 3 illustrates this motivation. The table contains three examples in which researchers developed and published design principles that researchers in other design settings subsequently used and published the results. These include the design theory nexus, ecosystem modeling, and conceptual modeling rules. Such “classic” future projections help confirm the future projectability of the original design theories or principles. The other two papers in Table 3 (the grammar-based process design method and the text-analysis framework) have strong projectability qualities but have not yet found future projections.

These strong qualities are not imaginary. Researchers confirmed the projectability of all five papers in Table 3. Researchers projected the design theories and principles at least once into their original design setting. Novel artifacts embodied these projections. In terms of worldmaking, each design developed an artifact that moved a local world closer to a possible world. Because most DSR processes include not only design but also artifact construction and evaluation, at least one projection is typical. While the projection process logic is ideal for future projections (projections other than the original), it still operates quite happily in the initial, original design projection. But, in the original case, we must be careful to distinguish the design process from the projection process because they can overlap.

The projection process logic helps one more clearly see how projection differs from design. In a deterministic design process (Pandza & Thorpe, 2010), the design process would usually take place before any projection logic applies. One designs *then* implements. This positioning also fits well with van Aken’s (2004) notion of object design versus realization design. In such a case, we project the design theory and design principles into a possible world. But design processes can also be iterative, emergent, adaptive, and participatory. In such a case, the design process and the projection process would overlap. We can see from the above that framing a projection process in a software engineering and project management approach does not eliminate adaptation, iteration, or stakeholder participation from the projection process (in particular, see the third and seventh elements in the process logic) because Goodman's (1978) worldmaking foundations build on human thought and social behavior. We make our own worlds. In such overlaps, design scientists also project a design process into the possible world along with the emergent design theories and design principles. For example, this broader concept of projection can represent the projection of van Aken's (2004) realization design, Pandza and Thorp's (2010) path-dependent and path-creation design, and the concomitant projectability of van Aken's (2004) process design. The process logic in Figure 1 shows how the basic notion of projection explains how some design processes are continuous. For example, Pentland and Feldman (2008) recognized that organizational routines are themselves generative. Stated differently, just because an artifact's designers may exit because they regard the projection as complete, it does not mean that the worldmaking will not continue.

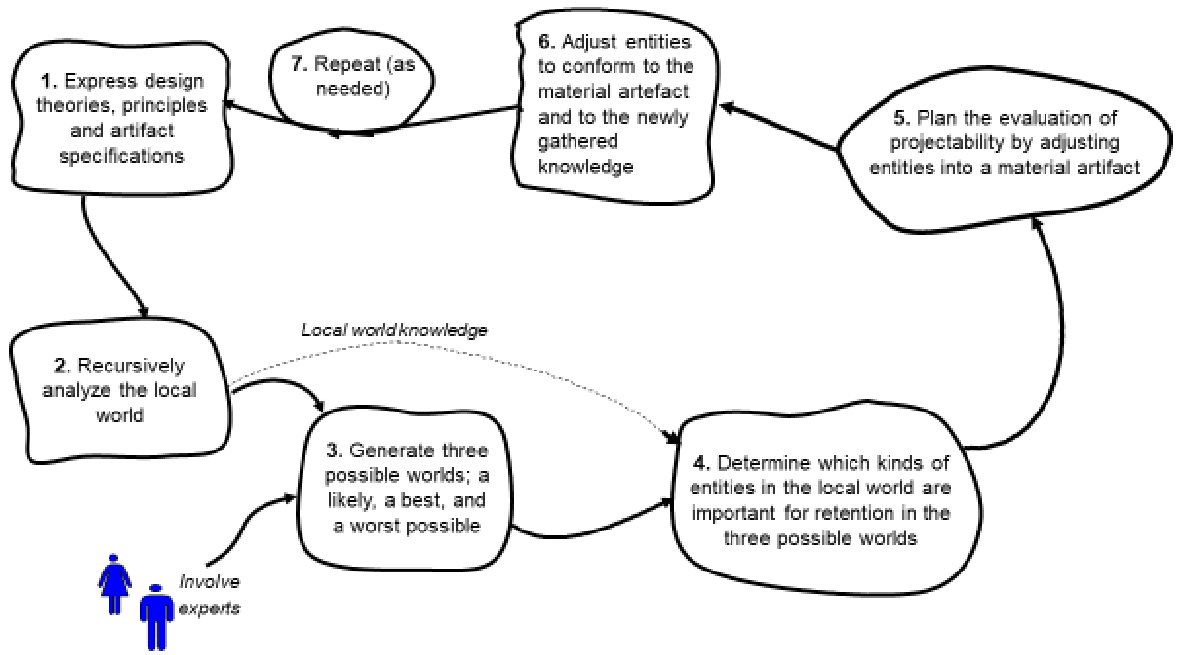

Figure 1. Projection Process Logic

6 Discussion

The projectability concept suits design science research well and offers certain advantages over the backward-looking generalizability. Primarily, projectability has a future orientation (i.e., a prescriptive orientation) that, as we show in this paper, suits design science better than the descriptive orientation of generalizability does.

6.1 Extending Existing Literature on Generalizability and Design Science

Our work extends, and partially contradicts, previous literature on generalizability and design science. For example, Rossi et al. (2012) assert that existing methods, such as Kuechler and Vaishnavi's (2008), determine the range of generalizability as a product of theorizing. Our work above suggests that these kinds of theory-based generalizations are too descriptive to be useful, and prescriptive frames (such as design science research) will depend more on novel concepts for the process, such as projectability.

The projectability concept also extends the literature about applying design principles and theories in practice. For example, Wieringa, Morah, and Morali (2012) suggest commencing with an artifact and then testing it by solving concrete, real-world problems. Such testing focuses on "bridg[ing] the gap between the idealizations made when designing and…real-world problems" (Wieringa et al., 2012, p. 220). Projectability concepts help to explain how such testing unfolds: if designers do not understand that they are projecting design principles across possible worlds, they may not be prepared to account for the closeness/distance between the two settings. Projectability extends the general what-if questions into more concrete evaluations of the spatiotemporal distance between different possible worlds. Wieringa et al. (2012) focus on “what would happen if the artifact would be transferred to the real world” (p. 230). Projectability extends this understanding to recognize that the artifact’s transfer will lead to possible worlds, and the actual (real) world at hand more or less represents a point of departure rather than a destination for the artifact.

In this paper, we show how projectability is a quality that one can find in design theories, principles, and artifacts. Such a quality provides a way to understand how one may project other design knowledge elements into possible worlds. For example, van Aken and others have distinguished between object designs, realization (or implementation) designs, and process designs (Drechsler, 2013; Huff et al., 2006; van Aken, 2004, 2007). Our work extends such design knowledge by offering a means by which object, realization, and process designs can each (or all) exhibit projectability.

Similarly, projectability concepts extend notions about tailorable technology, which Germonprez, Hovorka, and Collopy (2007, p. 354) define as “technology that is intentionally modified in the context of use”. We extend this idea with projectability concepts of virtuous cycles whereby design principles and the characteristics of possible worlds are brought into agreement with each other. Projectability explains how projection adjusts both the technology and the context, not just the technology. Designers choose from possible worlds that vary in distance according to the degree to which the context must change to agree with the technology and vice versa. The context and the technology tailor each to the other. This mutual tailoring specifically takes place in the DSR process logic that we describe in this paper.

6.2 Utility for Design Science Researchers

Projectability also helps explain how designers might wish to choose different system outcomes according to their design principles. That is, adapting design principles in alternative ways will lead to alternative possible worlds (some closer to and some more distant from the actual world). Germonprez et al. (2011) describe this chosen distance as systems bounds—design “within the planned bounds of the system” and “beyond the planned bounds of the system”. The former is comparable to a projection to a closer possible world. The latter risks more unintended consequences (possibly good, possibly bad) by projection to a more distant possible world.

Projectability’s focus on possible worlds easily draws attention to material artifacts’ potential practical and empirical roles. From this focus, we show above the way design theories and principles illuminate artifacts rather like how a streetlamp illuminates the surface below. We could label this viewpoint as vertical projectability: a design theory’s ability to help designers operate at a lower level of abstraction. Vertical projectability parallels theoretical-to-empirical generalizability that Lee and Baskerville (2003) propose. A theoretical-to-theoretical concept leads to horizontal projectability: to projecting design theories and principles as the basis for other design theories and principles. Such horizontal projectability would elaborate on existing work that conceptualizes the relationship between design theory, principles, and artifacts in a hierarchical way (e.g., Gregor & Hevner, 2013; Hanseth & Lyytinen, 2010) by adding a second dimension. Such a matrix viewpoint of projection would recognize how design theories project not only artifacts into possible worlds but also design theories themselves.

Artifacts differ. They may include technical, social, and informational components (Chatterjee, Xiao, Elbanna, & Saker, 2017) that have varying importance depending on the particular artifact in question. Consider, for example, a machine-learning algorithm, an enterprise information system, an e-healthcare system, and an agile project methodology—they all differ from one another. However, we believe that worldmaking and the IT process logic will apply for all different types. The logic that we describe in this paper does not differ for these four examples. The target group of users, the context they operate in, and the difficulty designing them varies widely. But we see that as part of analyzing the local world (second step in Figure 1).

As with any research, ours has several limitations. First, we used published cases to illustrate how the theory-based concepts and projectability processes can improve design science research. Because we anchor such arguments to descriptively analyzing how researchers have projected past work, we need future research to adopt or adapt projectability concepts in proactively formulating new projections. We also developed the projection logic from a software engineering perspective. This perspective provides a good foundation for DSR engaged in designing software artifacts, perhaps the most central kind of DSR artifact in IS. However, IS DSR also extends to developing other kinds of organizational and social artifacts. For DSR oriented to such other kinds of artifacts, the project management frame of our logic may seem deterministic, mechanistic, and unworkable. We need further research to examine other frames of logic for worldmaking projections of social and organizational design artifacts. For example, future research could investigate projection process logics that adopt an agile (Conboy, Gleasure, & Cullina, 2015), sociotechnical (Drechsler & Hevner, 2015), or co-creational (Vartiainen & Tuunanen, 2016) DSR frame.

7 Conclusion

The concepts and processes in projectability offer an alternative construction to using generalizability in design science research. As a demonstration, we build on the presence of unstated notions of design theory projection that have been marginalized in high-quality examples of design science research. Projectability provides a language to understand how design theories and design principles, as prescriptive constructs, imply intentionality for operation in other places or times. Consequently, these possible, local worlds will inhabit the present local world of the build-and-justify empirical basis of design science research. By providing such a language, along with concepts and processes, we can recognize, understand, and describe how design theories and principles do, or do not, project across space and time into other possible, local worlds.

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